

Cheyenne

Audience Data					
Cheyenne					
Rank	259				
				90%	
	Station	FM / AM	Audience(00's)	Audience(00's)	
1	KMUS	F	27	24	
2	KFBQ	F	13	12	
3	KLEN	F	13	12	
4	KFBC	A	8	7	
5	KRFX	F	6	5	
6	KRAE	A	3	3	
7	KCGY	F			

## U.S. Arbitron Data - 3 Up, 3 Down Test

Market		2 Up, 2 Down # Stations that Do Not Meet Criterion	3 Up, 3 Down # Stations that Do Not Meet Criterion
1	Seattle/Tacoma/Everett	1	1
2	Cleveland	1	Pass
3	Providence	1	Pass
4	Buffalo/Niagara Falls	1	1
5	Memphis	1	1
6	Las Vegas	1	Pass
7	Fresno	3	3
8	Little Rock	1	1
9	Charleston, SC	1	1
10	Spokane	2	2
11	Augusta	3	Pass
12	Madison	1	1
13	Reno	2	Pass
14	Erie	2	1
15	Columbus, GA	4	Pass
16	Lubbock	2	2
17	Burlington/Plattsburgh	1	1
		28	15
Total Stations		2192	2192
		1.28%	0.68%

## **APPENDIX B**

### **Supplement To Pioneer's Preference Request**

**Satellite CD Radio, Inc.  
Request for a Pioneer's Preference for  
Proposed Satellite Digital Audio Radio System**

**General Docket No. 90-357**

**PP-24**

**Filed June 2, 1993**

Before the  
FEDERAL COMMUNICATIONS COMMISSION  
Washington, D.C. 20554

In the Matter of:	)	
	)	
SATELLITE CD RADIO, INC.	)	GEN Docket No. 90-357
	)	RM-7400
Request for a Pioneer's Preference for	)	PP-24
Proposed Amendment of the Commission's	)	
Rules with Regard to the Establishment	)	
and Regulation of New Digital Audio	)	
Radio Services	)	

**SUPPLEMENT TO PIONEER'S PREFERENCE REQUEST**

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June 2, 1993

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## SUMMARY

CD Radio squarely fits within the pioneer's preference criteria adopted by the Commission. CD Radio is a small, entrepreneurial company that developed innovative solutions overcoming a host of transmission problems, allowing it economically to offer a desired new service to the public. Risking its time and resources, CD Radio publicly disclosed its blueprint for a satellite digital audio radio service in an effort to obtain a spectrum allocation for the service through the FCC's administrative processes. CD Radio fundamentally changed the landscape when it developed a method to make satellite DARS ubiquitously and seamlessly available throughout virtually all of CONUS. CD Radio also spearheaded efforts to find and clear spectrum for the service, to obtain international approval for use of the band, and to coordinate domestic deployment of satellite DARS with other countries to avoid interference. Due to these efforts, satellite DARS is approaching reality in the United States.

CD Radio believes that its singular technical and regulatory efforts warrant grant of a pioneer's preference. Indeed, the pioneer's preference policies were adopted to rectify the fundamental unfairness of allowing any company to compete for a new license on an equal basis with innovators, like CD Radio, that blazed technical and regulatory trails for new services. As discussed below, CD Radio has invested three years and approximately \$8 million in satellite DARS. CD Radio's pathbreaking efforts and perseverance should be rewarded.

CD Radio has also succeeded at the type of technological innovations that have characterized the Commission's pioneer's preference awards to date. CD Radio's novel use

of satellite spatial and frequency diversity and its innovations in satellite systems engineering overcome for the first time the technical barriers to launching a coast-to-coast seamless satellite DARS system for mobile users. These innovations also permit highly spectrally efficient operation, decrease the costs of providing the service substantially over conventional satellite architectures, redefine the state-of-the-art in mobile high-fidelity services, and enable a competitive market with four satellite DARS licensees. CD Radio's engineering advances facilitate a new era by allowing competitive delivery of low cost, CD-quality programming to mobile subscribers ubiquitously throughout the continental United States.

Importantly, CD Radio's innovative concepts exist more than merely on paper, and have been thoroughly proven out in real world experimentation. CD Radio has recently completed a second series of tests under an experimental authorization that conclusively demonstrate the reliability and soundness of CD Radio's designs for transmission of 30 stereo, CD-quality program channels to mobile units throughout the continental United States utilizing a spatial and frequency diversity satellite architecture. These tests also validated the performance of CD Radio's innovative silver dollar-sized planar array antennas and its mobile receiver in a multipath and fading environment typical of urban and suburban areas. Based on the results of CD Radio's tests, CD Radio is prepared to start system implementation as soon as it is granted a license by the Commission.

Both from a regulatory and a technical viewpoint, CD Radio merits a pioneer's preference. CD Radio urges the Commission to award it a tentative pioneer's preference expeditiously, followed by adoption of service rules that would allow CD Radio to implement its satellite DARS system as soon as practicable.

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Radio Services	)	

## SUPPLEMENT TO PIONEER'S PREFERENCE REQUEST

Satellite CD Radio, Inc. ("CD Radio"), by its attorneys, herewith submits a supplement to its pending request for a pioneer's preference.<sup>1</sup> By this filing, CD Radio further updates the record to reflect the work CD Radio has accomplished since its previous experimental report, including recently concluded S-Band experiments demonstrating the end-to-end technical feasibility of CD Radio's proposed design for a satellite digital audio radio service ("satellite DARS"). As discussed below, CD Radio warrants a pioneer's preference both for its extensive regulatory efforts to create satellite DARS and for its technical innovations, which allow the service to be offered ubiquitously, economically, competitively and with a minimal allocation of spectrum.

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<sup>1</sup> "Deadline to File Pioneer's Preference Requests For Satellite Digital Audio Radio Service," *Public Notice* No. DA 93-508 (May 3, 1993). CD Radio's pioneer's preference request was filed on May 18, 1990, and subsequently updated on January 23, 1992. See Application of CD Radio, Inc. at 39, File Nos. 49/50-DSS-P/L-90, 58/59-DSS-AMEND-90, 44/55-DSS-AMEND-92, PP-24 (filed May 18, 1990) ["*CD Radio Preference Request*"]; Satellite CD Radio Supplement to Request for Pioneer's Preference, GEN Docket No. 90-357, PP-24 (filed Jan. 23, 1992) ["*CD Radio Preference Supplement*"]. The Commission placed CD Radio's request on public notice for comment on January 31, 1992, and no opposition of any kind was received. See "Requests for Pioneer's Preference Filed," *Public Notice*, Report No. 21646 (Jan. 31, 1992).



## I. INTRODUCTION

### A. CD Radio's Pioneer's Preference Request

On May 18, 1990, CD Radio opened the history of the satellite digital audio radio service ("satellite DARS") in the United States by filing the first application to construct, launch, and operate a satellite system to provide high-fidelity digital music to mobile users across the continental United States. In so doing, CD Radio admittedly was not the first to *conceive* of digital radio services from space. In proposing a subscription-oriented, commercial offering, however, CD Radio was forced to design a practical and affordable service. Before CD Radio's efforts, no entity -- U.S. or foreign -- had accomplished this; indeed, several of the other applicants for satellite DARS licensing apparently still have not taken this step.

Specifically, satellite DARS formerly was conceived *solely* as a rural and remote offering: a "gap filler." Coast-to-coast coverage in suburban or urban areas was thought impossible because of blockage and multipath. Early designs ignored cities, and hypothesized a network of terrestrial stations augmenting the satellite signals.

As described in detail below, CD Radio's solution was satellite spatial and frequency diversity. Spatial and frequency diversity substantially mitigates the effects of blockage, multipath fading, and frequency-selective fading. Thus, for the first time, satellite DARS could offer nearly ubiquitous coverage throughout the CONTinental United States (CONUS). CD Radio's design permits satellite radio to achieve its full potential separate and apart from terrestrial services, at low cost and with a reduced interference potential. CD Radio's

approach is unmatched either abroad -- current Canadian plans envision satellite services as an adjunct to terrestrial digital radio -- or here at home -- DSBC's application relies on terrestrial augmentation;<sup>2</sup> AMRC's proposal, like that of its corporate cousin AMSC, is tailored principally to rural areas.<sup>3</sup>

As a result of this development, CD Radio requested a pioneer's preference for the service based in part on the technical solutions necessary to implement the above approach. Thus, to implement spatial and frequency diversity satellite technology, CD Radio pioneered development of silver dollar-sized planar array antennas, use of high efficiency perceptual audio coding compression techniques, and construction of an advanced mobile receiver. Collectively, these innovations permit satellite DARS to be offered seamlessly, in both urban and rural areas; decrease the costs of providing satellite DARS; provide a high standard of spectrum efficiency; allow spectrum sharing by four competitive satellite DARS providers; and enable a new and high-fidelity audio service for mobile subscribers.

CD Radio's pioneering achievements have not been limited to its considerable technical successes, however. For over three years, while other companies postponed commitment until a spectrum allocation was probable and the technology for satellite DARS was shown by CD Radio to be practical, CD Radio spearheaded the administrative and regulatory processes that found and cleared spectrum in the S-Band for satellite DARS, both nationally and internationally. CD Radio's singular dedication of time and resources to

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<sup>2</sup> Application of Digital Satellite Broadcasting Corporation For a Digital Audio Radio Service Satellite System, App. D at 2, File Nos. 28-DSS-LA-93, 12/13-DSS-P-93 (filed Dec. 15, 1992).

<sup>3</sup> Reply and Opposition of American Mobile Radio Corporation at 6, File Nos. 26/27-DSS-LA-93, 10/11-DSS-P-93 (filed May 21, 1993).

launch satellite DARS has directly culminated in last year's proposal to allocate spectrum for satellite DARS. No other party spent resources on *regulatory* efforts, but three others are now benefiting from CD Radio's labor. The Commission can -- and should -- license free riders, but it should not anoint them as pioneers.

The principal purpose of the instant filing is to supplement CD Radio's pioneer's preference request with the experimental report attached as Appendix A. This report closes a significant chapter in the history of satellite DARS by demonstrating conclusively the technical feasibility of CD Radio's technology for satellite DARS. As discussed below, CD Radio is the only applicant for a satellite DARS license that has fully developed and tested a system design. CD Radio is ready to deploy its technology and, in fact, recently requested authorization under Section 319(d) of the Communications Act to allow it to preconstruct elements of its satellite DARS system and further expedite the arrival of satellite DARS for American consumers.<sup>4</sup> CD Radio's considerable technical and regulatory efforts to launch satellite DARS warrant grant of a pioneer's preference.

#### **B. CD Radio's Satellite DARS System Design**

CD Radio's proposed service will offer 30 channels of commercial-free digital music over the air to mobile and fixed users ubiquitously throughout CONUS. CD Radio begins by

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<sup>4</sup> See Letter from Lawrence F. Gilberti, President, Satellite CD Radio, Inc., to Donna R. Searcy, Secretary, Federal Communications Commission in re: Request for Waiver of Section 319(d) (dated May 17, 1993).

selecting tracks for each narrowcast program channel<sup>5</sup> and compressing the 1.5 Mb/s digital information representing the music into 128 kb/s perceptual audio coded digital data.<sup>6</sup> These compressed tracks are assembled into a continuous data stream; multiplexed together with other channels of narrowcast programming and a 128 kb/s system control channel; convolutionally encoded for error correction; interleaved; and uplinked to CD Radio's multiple diversity satellites using C-Band frequencies. The information is then retransmitted by satellite to mobile and fixed subscribers in the S-Band.

Unlike previous satellite systems for wide-area data delivery, CD Radio's proposed architecture for satellite DARS will utilize two high-elevation geostationary full-CONUS satellites located at 80° and 110° West Longitude. Each satellite will transmit an identical digital stream to a subscriber receiver in the S-Band, although each data stream will be offset in frequency to achieve diversity. In total, CD Radio's system utilizes two 8 MHz channels, which can be interleaved with other channels as long as all satellite DARS providers coordinate use of cross-polarization to avoid interference. In this manner, four providers will be able to operate independent competitive systems within the spectrum proposed for satellite DARS.

Only authorized subscribers will be able to receive CD Radio's transmissions. The subscription process is both fast and convenient, however, and a potential listener equipped with a CD Radio compatible mobile receiver can call a toll-free number to have service

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<sup>5</sup> Narrowcast programming utilizes the large number of channels available in CD Radio's design to specifically target "narrow" customer groups. In this manner, CD Radio's system can offer specific programming tailored for, as an example, Hispanic listeners.

<sup>6</sup> Perceptual audio coding, or PAC, is described in further detail in Appendix A, §3.3.2 & Attachment A4.

initiated within minutes. The mobile equipment consists of a silver dollar-sized planar array antenna and a data decoder and decompressor, which CD Radio plans to incorporate into factory-installed and after-market automobile radios. CD Radio's system could also be interconnected with a residential stereo or a "boom box" for fixed operation.

CD Radio has now completed the second series of experimental tests of this satellite DARS system design. The first series, known as the Early Bird tests, were conducted throughout October and November of 1991 and confirmed the practicality of important CD Radio concepts and engineering approaches.<sup>7</sup> Based on the data obtained during the Early Bird tests, CD Radio was able to refine its satellite DARS equipment and incorporate additional technological advances. To ensure the performance of the latest evolution of its equipment designs in the band actually proposed for satellite DARS, CD Radio recently completed a second, comprehensive series of real world tests. These recent tests have fully validated CD Radio's technology for its proposed satellite DARS system architecture, providing the ultimate demonstration of technical feasibility.

## **II. CD RADIO WARRANTS A PIONEER'S PREFERENCE FOR ITS DEVELOPMENT OF SATELLITE DARS**

CD Radio warrants a pioneer's preference for satellite DARS because it both created the service and the technology that will allow the service to be brought to the CONUS ubiquitously, inexpensively, and rapidly. CD Radio was the first ever applicant for satellite DARS. CD Radio also was, by a two and one half year margin, the first to propose high

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<sup>7</sup> The results of the Early Bird tests were reported to the Commission on January 31, 1992. See *Pioneer's Preference Supplement* at Exhibit A.

quality satellite DARS offered across the continental United States effectively and at a low cost. In those two and one half years, CD Radio, without the aid of any other purported "pioneers," committed its time and resources in a campaign at the FCC, with incumbent spectrum users, and internationally at WARC-92 to seek out and free spectrum for mobile satellite DARS. CD Radio also developed the technological foundation for the service that is now being duplicated by other applicants. In particular, CD Radio's entirely new spatial and frequency diversity mobile satellite architecture and other advances in satellite DARS redefine the state of the art by bringing the benefits of satellite DARS to both urban and rural subscribers across the United States and within the financial reach of average Americans. These achievements warrant grant of a nationwide pioneer's preference.<sup>8</sup>

**A. CD Radio's Extensive Administrative and Regulatory Efforts to Obtain Spectrum and Develop Rules for Satellite DARS Warrant Grant of a Pioneer's Preference**

CD Radio has been, and continues to be, the industry leader in the development of satellite DARS. CD Radio's application to provide satellite DARS pre-dated other applicants *by over two and a half years*. During those two and a half years, while other companies had yet to perceive the potential of satellite DARS, CD Radio was actively forging ahead through the regulatory process required to deliver the service to the public. CD Radio, alone among

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<sup>8</sup> In the *Pioneer Preference Order*, the Commission indicated that it would consider granting such nationwide preferences "[w]here a service is inherently nationwide." *Procedures to Provide a Preference to Applicants Proposing an Allocation For New Services*, 6 F.C.C. Rcd 3488, 3495 (1991) [*"Pioneer's Preference Order"*], *recon.*, 7 F.C.C. Rcd 1808 (1992) [*"Pioneer's Preference Recon."*], *further recon.*, 8 F.C.C. Rcd 1659 (1993). In this regard, the Commission has already implicitly determined that satellite systems are "inherently nationwide." *Low-Earth Orbit Satellites*, 8 F.C.C. Rcd 1812 (1993). For this reason, CD Radio believes that satellite DARS is "inherently nationwide" and therefore that it should be awarded a nationwide pioneer's preference.

the other satellite DARS applicants, worked with the FCC, the Administration, and the aeronautical industry -- both nationally and at WARC '92 -- to identify and create the allocation at S-Band for satellite DARS. CD Radio's efforts have blazed the trail that other satellite DARS applicants are now pursuing.

The Commission's preference policies were intended to recognize the type of regulatory accomplishments that CD Radio has achieved. Specifically, the policies were adopted to redress the unfairness of the then-existing allocation policies towards innovators:

[W]hen an innovator, especially a small entity, develops an idea for a new service, it cannot simply arrange for developmental funding and try its idea in the market. Rather, it must first request that the Commission allocate spectrum or change some technical standards, thus making the idea public, and then compete with other parties for a license. . . . [D]uring the proceeding to allocate spectrum or change technical standards, others--perhaps larger companies with greater resources--can evaluate the proposed new service and, if the rule making is successful, compete for a license at the same time as the original petitioner. . . . [T]he governmental process thus undermines the competitive edge that would normally accrue to the innovator. . . .<sup>9</sup>

The Commission observed, in fact, that while technical accomplishments are a leading indicator of pioneering achievement, a new service is far more than mere application of a new technology:

[W]e will not consider a request for a pioneer's preference simply for the introduction of a new technology. . . . Unless a new technology is associated with a licensable service, there is

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<sup>9</sup> *Establishment of Procedures to Provide a Preference to Applicants Proposing an Allocation For New Services*, 5 F.C.C. Rcd 2766 (1989) (Notice of Proposed Rulemaking) ["Pioneer's Preference Notice"].

little opportunity for the Commission to create a system of rewards to encourage its implementation.<sup>10</sup>

Recognizing that "[i]nnovators of new services must spend a considerable amount of time and money in order to develop these services,"<sup>11</sup> a pioneer's preference "provide[s] innovators and financial institutions with sufficient certainty"<sup>12</sup> and "ensure[s] that innovators have an opportunity to participate . . . in new services that they take a lead in developing."<sup>13</sup> The goal of the policies is thus the development of new and innovative *services*, which entails dedication of time and resources beyond refining technology.

CD Radio embodies the qualities these policies seek to reward. CD Radio has invested over three years and approximately \$8 million in a continuous struggle to realize its vision of satellite DARS. Acting on its conviction that it could transform its creative engineering concepts into reality, CD Radio convinced the financial community of the merits of the service, rebutted the claims of naysayers and established service providers, defended the technical merits of the service in the crucible of the adversarial process, and surmounted the many other obstacles standing in the way of providing satellite DARS to the public. In particular, CD Radio spearheaded administrative, regulatory, and industry efforts to clear a path for future satellite DARS providers:

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<sup>10</sup> *Pioneer's Preference Order*, 6 F.C.C. Rcd at 3492 (footnote omitted). The Commission similarly observed that developers of new technology can be assured of financial compensation for their ideas through intellectual property laws, but that "no system exists for rewarding those who develop new frequency-based services." *Pioneer's Preference Notice*, 5 F.C.C. Rcd at 2766.

<sup>11</sup> *Pioneer's Preference Notice*, 5 F.C.C. Rcd at 2766.

<sup>12</sup> *Pioneer's Preference Order*, 6 F.C.C. Rcd at 3494.

<sup>13</sup> *Id.* at 3488.



- ▶ CD Radio took the first step in creating satellite DARS by filing the first ever application for a satellite DARS system in May of 1990; the remaining applications were not filed until two and one half years later -- after the December 1992 cut-off notice.
- ▶ CD Radio subsequently filed a petition for rulemaking to allocate spectrum and develop rules for a satellite DARS.
- ▶ CD Radio worked extensively with the FCC and the Executive Branch to find spectrum for satellite DARS, and struck a historic compromise with the aeronautical and defense industries to clear a portion of the S-Band for satellite DARS.
- ▶ CD Radio worked with the U.S. government to obtain an international allocation for satellite DARS at the 1992 World Administrative Radio Conference.
- ▶ CD Radio was instrumental within the CCIR U.S. Study Group to develop proposed standards for satellite DARS and for international coordination of satellite DARS.
- ▶ CD Radio actively participated and contributed time and resources to EIA committee efforts to develop and test digital audio radio standards in the U.S.
- ▶ CD Radio developed and proposed a technically feasible multiple entry scheme for satellite DARS that would create spectrum opportunities for four competitive providers.

Now that a spectrum allocation is imminent, others have professed an interest in satellite DARS. CD Radio welcomes this company and looks forward to a competitive marketplace. But, the competitors are "johnny-come-latelys": even though CD Radio's own pioneer's preference request was placed on public notice, it was ignored by those companies that now are competing with CD Radio for satellite DARS licenses. Thus, even one and a half years after CD Radio first staked its claim to being a pioneer, after considerable regulatory advances by CD Radio, and only a few months before adoption of the NPRM, these companies had not even become engaged to the point of being able to comment on CD

Radio's preference request. Indeed, CD Radio is the *only* pioneer's preference applicant at the Commission ever to have completed the public comment cycle without *any* formal opposition.

The pioneer's preference process was intended to mitigate the disincentives to introducing new service concepts posed by the Commission's spectrum allocation process. By awarding a pioneer's preference to CD Radio, the Commission would allow CD Radio to recoup the investment it has made to bring satellite DARS to fruition, and hold out a similar promise to other nascent companies harboring new and innovative ideas. Grant of a pioneer's preference to CD Radio would encourage others to accept the burdens of leading the development of a wealth of new services -- and the years of uncertainty and zero revenue -- by offering the assurance of receiving a license if the service is finalized.

Only four applicants for satellite DARS remain, and it appears that all could be licensed in the spectrum available if they adopt CD Radio's methodology. The Commission should rapidly grant licenses to all qualified applicants. However, at the same time, the agency should -- in accordance with its rules -- confer on the industry leader and innovator the mantle of pioneer. To ensure that the distortion and delay of the regulatory process do not stifle creative and innovative ideas for use of the spectrum, CD Radio should be awarded a pioneer's preference.

**B. CD Radio's Development of Innovative New Technologies To Enable the Introduction of Satellite DARS Warrants Grant of a Pioneer's Preference**

In addition to its regulatory and administrative accomplishments to transform satellite DARS from abstract concept to reality, CD Radio also pioneered the new technologies that enable the introduction of low cost, high quality digital audio radio services. CD Radio's unique spatial and frequency diversity mobile satellite system design, in particular, significantly reduces signal blockage, mitigates multipath degradation, and resists frequency-selective fading, thus allowing higher quality and more spectrum efficient operations than possible using a non-diversity mobile satellite architecture. Furthermore, CD Radio's satellite system technology includes design and development of innovative, extremely small planar array antennas; innovative application of perceptual audio coding techniques; and designing and subsequently constructing an original, highly advanced mobile receiver. These technical innovations, discussed in further detail in the attached "CD Radio DARS Technology Innovations,"<sup>14</sup> warrant grant of a pioneer's preference.

**1. CD Radio is responsible for a number of innovative advances in satellite system technology.**

In its *Pioneer Preference Order*, the Commission indicated that a pioneer's preference would only be granted to "an entity that demonstrates that it . . . has developed an innovative proposal that leads to the establishment of a service not currently provided or a substantial

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<sup>14</sup> See Appendix B.

enhancement of an existing service."<sup>15</sup> As discussed further below, CD Radio's innovations in the use of spatial and frequency diversity, its innovations in development of planar array antennas, its application of perceptual audio coding, and its development of an advanced mobile receiver satisfy the Commission's requirements for obtaining a preference.

*a. CD Radio's innovative satellite spatial and frequency diversity design merits a pioneer's preference.*

As mentioned above, CD Radio has pioneered seamless satellite DARS service through satellite spatial and frequency diversity. As discussed in Appendix A,<sup>16</sup> CD Radio's satellite DARS system utilizes two S-Band satellites, at 80° and 110° West Longitude, which transmit identical interleaved digital data streams at frequencies offset by approximately 20 MHz. When the signals are received by the mobile unit, each data stream is individually amplified, down converted, demodulated, and the two signals are time phased together using a maximal ratio combiner and then de-multiplexed.

CD Radio's entirely novel satellite design fosters, for the first time, virtually seamless satellite radio coverage of urban, suburban and rural areas. In particular, the design has a number of important advantages for mobile satellite DARS:

- ***CD Radio's spatial diversity architecture reduces signal blockage.*** Due to the propagation characteristics of the S-Band, objects obscuring the line-of-sight between the satellite and the receiver, such as tall buildings, trees, and overpasses, can cause severe signal degradation or complete signal loss that is

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<sup>15</sup> *Pioneer Preference Order*, 6 F.C.C. Rcd at 3494.

<sup>16</sup> *See, generally*, Appendix A at Attachment A2.

objectionable to listeners.<sup>17</sup> As discussed further in Appendix B, by using satellite spatial diversity with high satellite elevations, CD Radio has achieved substantial blockage reduction, allowing the offering of satellite DARS ubiquitously, not just in rural areas where minimal blockage problems exist.<sup>18</sup>

- ▶ ***CD Radio's design provides approximately 9 dB improvement over non-diversity designs for satellite DARS by mitigating multipath degradation.*** CD Radio designed the satellite DARS mobile units to receive independent transmissions from two satellites, and select the strongest signal or combine them. As explained in Appendix B, CD Radio's multiple satellite diversity reduces the fade margin an estimated eightfold (*i.e.*, 9 dB) over the margin required for a single satellite path.<sup>19</sup>
- ▶ ***CD Radio's design provides approximately 3 dB improvement over non-diversity designs for satellite DARS through resistance to frequency-selective fading.*** For the path lengths needed for geosynchronous space-to-earth segments and frequencies above 2 GHz, the differential effect of frequency-selective fading conditions can be severe and persist throughout several megahertz. CD Radio's frequency diversity system shows extremely substantial resistance to fading conditions and, in fact, if neither signal is blocked or faded, the effective combined signal to noise ratio would actually be improved by 3 dB over the margin needed for a single space-to-earth path.<sup>20</sup>

Consequently, the innovative use of satellite spatial and frequency diversity makes the service viable, offers exceptional transmission, and allows a lower link power budget than conventional satellite distribution architectures. Importantly, these improvements have been

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<sup>17</sup> The number, frequency, and length of such interruptions is dependent upon factors that include the vehicles's speed and the elevation angle from the vehicle to the satellite. Importantly, none of these factors can practically be altered by the satellite DARS provider at the vehicle. Because satellite DARS is intended to operate in a nomadic mobile environment, blockage cannot be eliminated by simple strategic positioning of the receiver, as is done for fixed services. CD Radio also investigated using two receiver antennas to combat blockage, but the diversity separation that can be achieved on an automobile rooftop did not significantly improve blockage.

<sup>18</sup> Appendix B at 3.

<sup>19</sup> *Id.* at 4.

<sup>20</sup> *Id.* at 5.

validated and empirically measured in CD Radio's recent field trials.<sup>21</sup> In conjunction, these factors enable CD Radio to offer an economic, high quality service to subscribers.

***b. CD Radio should be granted a pioneer's preference for its satellite systems integration advances.***

In addition to its novel multiple diversity satellite system architecture, CD Radio has also integrated a number of other advanced technologies into its satellite DARS system. CD Radio, for example, has implemented the following innovations:

- ▶ ***Use of planar array antenna technology.*** In order to meet the size and cost considerations for mobile satellite DARS, CD Radio developed an extremely small planar array antenna. CD Radio's planar array antenna has a radius less than 1" and measures approximately 0.1" thick. Yet, CD Radio's planar antenna has the technical characteristics needed to operate with CD Radio satellite DARS.<sup>22</sup>
- ▶ ***Use of perceptual audio coding to compress audio data.*** In order to maximize use of the spectrum available for satellite DARS, CD Radio worked with AT&T-Bell Laboratories to incorporate a highly sophisticated technique for compressing audio signals into a satellite DARS environment. Perceptual audio coding ("PAC") compression algorithms selectively remove information from digital audio tracks based upon extensive research into what aspects of music individuals actually perceive. By eliminating data that represents sounds that listeners do not actually "hear," PAC techniques can achieve compression of approximately 12:1 while maintaining CD-quality.<sup>23</sup>
- ▶ ***Design, construction, and testing of the first advanced mobile satellite DARS receiver.*** In developing its satellite DARS system design, CD Radio spent a great deal of time ensuring that the user interface to the system was functional as well as ergonomic. CD Radio's labors have culminated in the design, construction, and testing of the first advanced mobile satellite DARS receiver

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<sup>21</sup> Appendix A at §4.3.6.

<sup>22</sup> See *Id.* at §3.3.4.

<sup>23</sup> *Id.* at §3.3.2 & Attachment A4.

for automotive applications. CD Radio's mobile satellite receiver blends, for the first time, the technology needed to decode satellite DARS signals, including the dual channel reception/amplification/down conversion, multiplexing and PAC/digital to analog decoding, with conventional automobile radio features.<sup>24</sup>

In conjunction, the advantages offered by CD Radio's systems integration uniquely enables CD Radio to offer a high quality, low cost, and spectrum efficient service to the public.

**2. CD Radio's innovations enable the introduction of a high quality, low-cost satellite DARS.**

Throughout the history of the pioneer's preference, the Commission has emphasized that technological development alone is not the equivalent of innovation. To pioneer requires technical innovation related to a licensable service, or:

[A]n added functionality provided to a broader group of customers than was previously available or a new technology that permits 1) increased ability to perform an existing work requirement; 2) increased capacity in an existing service; 3) a substantial cost reduction in an existing service; 4) improved quality of an existing service.<sup>25</sup>

In applying these criteria, the Commission also stated:

[T]echnologies that yield efficiencies in spectrum use, speed or quality of information transfer, or spectrum sharing, or which significantly reduce costs to the public, will be given careful consideration [for a pioneer's preference].<sup>26</sup>

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<sup>24</sup> *Id.* at §3.3.5.

<sup>25</sup> *Pioneer Preference Order*, 6 F.C.C. Rcd at 3494.

<sup>26</sup> *Id.*

CD Radio's technical accomplishments allow it to provide satellite DARS on a spectrally efficient basis, at an extremely low-cost of service, and with state-of-the-art digital sound quality. In so doing, CD Radio's innovations advance the Commission's pioneer's preference goals in the following ways:

- ▶ ***CD Radio's system extends satellite DARS from a "gap filler" to a seamless, ubiquitous service.*** Until CD Radio proposed spatial and frequency diversity, models of satellite DARS had been limited to rural areas with little signal blockage or multipath, relying on terrestrial augmentation in cities and suburbia. CD Radio's design is the only system permitting true CONUS portability of satellite DARS receivers.
- ▶ ***CD Radio's system is highly spectrum efficient.*** CD Radio's architecture would allow diversity transmission of 30 channels of CD-quality audio programming, in conjunction with a 128 kb/s control channel, in two 8 MHz channels. This system design offers the highest practical spectrum efficiency for CD-quality audio transmission.
- ▶ ***CD Radio's low-power satellite system architecture provides significant spectrum sharing and coordination advantages.*** As discussed in Appendix B, CD Radio's proposed architecture reduces the required link power budget for space-to-earth transmission by 16 times. Lower power requirements enable greater sharing capability and may well be the *only* means of meeting a realistic power flux density limit along the southern Canadian border to avoid interference.<sup>27</sup>
- ▶ ***CD Radio's satellite DARS system design lowers service costs.*** CD Radio's unique satellite DARS design enables the absolute lowest cost infrastructure. By reducing the radiated power requirements for the satellites, CD Radio has reduced its satellite system cost by \$250 million.<sup>28</sup> CD Radio's intensive

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<sup>27</sup> CD Radio has previously provided an exhaustive analysis of Canadian coordination. In addition, the U.S. CCIR Study Group also analyzed coordination with Canada, in the Attachment to U.S. CCIR Document 10-11S/99E, which was annexed to CD Radio's rulemaking comments. See also Appendix B at 4.

<sup>28</sup> CD Radio estimates the cost of designing, launching, and operating a single space-to-earth link from at approximately \$500 million. Appendix B at 2. Based on CD Radio's contract price with Space Systems/Loral for the design and construction of its two satellite system, CD Radio's satellite system cost, including launch, is estimated at only \$250 million.



engineering design work allows it to offer the public a satellite DARS receiver for approximately \$200-\$300, and 30 channel service at only \$5-10/month.

Thus, CD Radio's technical accomplishments directly enable the offering of technically feasible and commercially practical satellite system for distribution of digital, high-fidelity sound to mobile users in both urban and rural areas across the continental United States.

### **III. THE TECHNICAL FEASIBILITY OF THE CD RADIO SATELLITE DARS INNOVATIONS HAS BEEN EMPIRICALLY DEMONSTRATED**

In adopting pioneer's preferences, the Commission emphasized that it did not intend to grant preferences based upon speculative technology. The Commission, in fact, considered requiring preference requests to be based on actual experimental results, but ultimately concluded that it was conceivable that an innovation could be feasible in the absence of an experiment. Notwithstanding the Commission's ultimate conclusion, however, it emphasized the importance of real world results:

We continue to believe that while performance of an experiment generally will be extremely beneficial, since in most cases a substantially different technology or service will be proposed, it should not be absolutely required as a prerequisite to obtaining a preference. We disagree with NAB that requiring only a technical showing means that a preference could be based on mere speculation that a technology might work and result in technically inferior services. We intend to analyze technical showings as rigorously as the results of experiments to ensure that a preference applicant's proposed new service or technology is viable and worthy of a preference.<sup>29</sup>

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<sup>29</sup> *Pioneer's Preference Recon*, 7 F.C.C. Rcd at 1809.